Question			Expected Answers	Mark	Additional Guidance
1	(a)		0.096 **; ;** tonnes ha^{-1} y^{-1} **;**	**3**	If answer is incorrect **CREDIT** one mark for correctly identifying a difference of 4.3 (tonnes ha^{-1}) **ACCEPT** tonnes per hectare per , year **ACCEPT** tonnes ha^{-1}/yr **ACCEPT** tonnes ha^{-1} per year **IGNORE** annum

Question			Expected Answers	Mark	Additional Guidance
1	(b)		**1** crossbreed / breed / interbreed , high-yielding , wheat plants / individuals **;** **2** assess / test / measure , yield / AW **;** **3** crossbreed / AW , selected / best / high-yielding , offspring **;** **4** over generations **;** **5** marker assisted selection / prevent self-pollination / genetic screening / prevent unwanted (cross) pollination **;**	**4 max**	**1 ACCEPT** breed high-yielding individuals **1 ACCEPT** 'mate / reproduce' as AW for 'breed' **1 IGNORE** inbreed **1 ACCEPT** description of high-yielding plant, e.g. more , ears / grain / seed / wheat **1 ACCEPT** if only one of the plants is high-yielding **2 IGNORE** select the best offspring **4 ACCEPT** several / a few generations **4 IGNORE** time **5 ACCEPT** descriptions **5 IGNORE** the ones with the correct gene **5 ACCEPT** prevent self-fertilization
1	(c)		(use of) fertiliser **;** (use of) pesticide / fungicide / insecticide **;** improved technology **;**	**2 max**	**IGNORE** prompt lines and mark as prose **IGNORE** refs to climate change **IGNORE** crop rotation **IGNORE** increase in soil minerals **IGNORE** irrigation **ACCEPT** selective herbicide **IGNORE** decrease in pests **ACCEPT** e.g. better harvesting technology **IGNORE** genetic modification / irrigation
			Total	**[9]**	

Question			Answer	Marks	Guidance
2	(a)	(i)	geographic(al) **;**	**1**	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **ACCEPT** ecological **IGNORE** physical / barrier
	(a)	(ii)	genetic drift **;**	**1**	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
	(a)	(iii)	*C because* has the greatest change in allele frequency / described**;** smaller population / fewer individuals **;** *idea that* more **,** subject to founder effect / unrepresentative at start **;** *(more subject to genetic change because)* each random mating more significant **or** each individual forms a greater proportion of gene pool **or** each individual has greater effects on gene pool (than in large population) **or** easier to lose allele from gene pool;	**2 max**	**If C not identified then no marks awarded** **Look for comparative points with other populations** **ACCEPT** p and q for allele eg 'frequency of allele in C changed by 0.20 whilst it changed by 0.02 in A and 0.14 in B' **ACCEPT** figs as % **ACCEPT** smallest /fewest

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>2</td><td>(b)</td><td>(i)</td><td>1401 ; ; ;</td><td>3</td><td>Correct answer = 3 marks

Award 2 max
if answer not given to the nearest whole number or is incorrect or missing,
then

CREDIT correct working in table columns as follows:
both figures in one column correct = 1 mark. (N.B. Minus sign required for column 1)

ALLOW ecf from any incorrect column to 2 max

<table>
<tr><th>Phenotype of fly</th><th>O - E</th><th>$(O - E)^2$</th><th>$\frac{(O - E)^2}{E}$</th></tr>
<tr><td>red eye, yellow body</td><td>- 354</td><td>125316</td><td>348 (348.100)</td></tr>
<tr><td>pink eye, yellow body</td><td>341</td><td>116281</td><td>323 (323.003)</td></tr>
<tr><td>red eye, ebony body</td><td>369</td><td>136161</td><td>378</td></tr>
<tr><td>pink eye, ebony body</td><td>- 356</td><td>126736</td><td>352</td></tr>
</table>
</td></tr>
<tr><td></td><td>(b)</td><td>(ii)</td><td>reject hypothesis because
calculated χ^2 value / 1401 , is (much) larger than , critical value / 11.35 ;</td><td>1</td><td>ALLOW ecf for a correct explanation that corresponds to the candidate's incorrect calculation for (b)(i)

CREDIT idea that probability that these results are due to chance is (much) less than 1% / 0.01</td></tr>
</table>

Question			Answer	Marks	Guidance
2	(b)	(iii)	(autosomal) linkage **or** genes / alleles, are linked **;** on same chromosome **;** linked alleles inherited together **;** **Ry** and **rY** (on chromosomes in heterozygotes) **;** crossing-over produced (rare) recombinants **;** tight linkage / two genes close together **;**	**3 max**	**DO NOT CREDIT** sex linkage **IGNORE** epistasis **ACCEPT** annotated drawing **ACCEPT** recombinant phenotypes described **ACCEPT** loci close together **Note** '*The alleles R & y and r & Y are inherited together*' = 2 marks (mps 3 & 4) '*The alleles for red eyes and ebony body, and pink eyes and a yellow body, are inherited together*' = 2 marks (mps 3 & 4)
			Total	**11**	

Question			Answer	Mark	Guidance
3	(a)	(i)	udder size / milk production / meat production / growth rate / muscle (as proportion of body mass) **;**	1	**ACCEPT** number of offspring per birth **IGNORE** unqualified references to size **IGNORE** references to , horns / placidity , unless the answer links this with more energy diverted to productivity
	(a)	(ii)	**1** artificial selection **;** **2** (selection of) named desired feature (linked to productivity) **;** **3** (cross)breed , selected / AW , cattle ; **4** (cross)breed**,** best / selected / AW, offspring **;** **5** over (many) generations **;**	4 max	**1 IGNORE** 'selective breeding' as mentioned in part (i) **2 ACCEPT** e.g. weigh them / measure them / see who produces the most milk / choose the biggest / udder size **2 IGNORE** select the best **2 CREDIT** marker assisted selection / progeny testing **2 DO NOT CREDIT** if clearly not in the context of selective breeding, e.g. change their diet to make them produce more milk' **3 ACCEPT** 'parents' as AW for 'cattle' **3 ACCEPT** 'reproduce / mate / interbreed' as AW for 'breed' **3 DO NOT CREDIT** inbreed **2&3** 'breed cattle with high milk productivity = 2 marls **4 IGNORE** 'crossbreed offspring' without qualification. Answer must imply some selection of offspring. **5 DO NOT CREDIT** few **5 ACCEPT** several
	(b)	(i)	(contains) all / each , of , nutrients / food groups **;** in correct proportions / AW **;**	2	**ACCEPT** a list of food groups that contains at least – protein, fat, carbohydrate, vitamins, minerals **IGNORE** components **ACCEPT** right amount of

Question			Answer	Mark	Guidance
3	(b)	(ii)		3	**Mark the first answer on each prompt line.** If the answer is correct and another answer is given that is incorrect or contradicts the original answer, then = **0 marks**
			A glycerol **;**		**A IGNORE** molecule
			C <u>unsaturated</u> fatty acid **;**		**C ACCEPT** unsaturated hydrocarbon , tail / chain
			D <u>ester</u> , bond / link **;**		**D IGNORE** covalent

Question			Answer	Mark	Guidance
3	(b)	(iii)	**1** contains **,** large amounts of energy / more energy than individual needs **;** **2** increased , fat / lipid , deposition / storage **;** **3** (associated with) obesity **;** **4** (lots of meat and dairy in diet could mean) lack of other (named) food groups / AW **;**	3 max	**1 ACCEPT** contains , too many calories / excess energy **1 ACCEPT** contains a lot of saturated fat **2 ACCEPT** in context of arteries and adipose tissue **2 ACCEPT** cholesterol / LDL as AW for fat **2 IGNORE** build up **3 IGNORE** CHD (as not malnutrition) **4 ACCEPT** nutrients as AW for food groups **4 IGNORE** unbalanced diet **4 IGNORE** fat / protein
3	(c)		**1** reduces , water potential / Ψ , outside , microbial / bacterial / fungal , cells **;** **2** (microbes) lose water **and** cannot , reproduce / survive / carry out metabolic reactions / AW **;** **3** water moves by osmosis **;**	3	**1** Cannot be implied from references to water potential gradient **1 ACCEPT** reduces beef water potential **1 IGNORE** solute potential **1 IGNORE** viruses **2 ACCEPT** bacteria lose water and die **2 AWARD** only in context of microbes dehydrating **2 IGNORE** viruses **2 IGNORE** beef losing water so microbes cant reproduce **3 ACCEPT** in any correct water potential context
			Total	**16**	

Question			Expected Answer	Mark	Additional Guidance
4	(a)		<table><tr><th>Explanation</th><th>Letter</th></tr><tr><td>One gene with two alleles. The alleles show codominance.</td><td>A ;</td></tr><tr><td>One gene with two alleles, located on an autosome (gene not sex linked). One allele is dominant and the other is recessive.</td><td>E ;</td></tr><tr><td>Two genes for two different characteristics on two different chromosomes.</td><td>D ;</td></tr><tr><td>A sex linked gene with a dominant and a recessive allele.</td><td>B ;</td></tr><tr><td>Epistasis, where two genes interact to affect one phenotypic character.</td><td>C ;</td></tr></table>	5	**Mark the first answer in each box.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**

Question			Expected Answer	Mark	Additional Guidance
4	(b)	(i)	$q^2 = 15 \div 60$ or 0.25 ; $q = \sqrt{0.25}$ or 0.5 ; (p =) 0.5 ;	3	**Correct answer (0.5) = 3 marks** even if no working shown **No mark for incorrect q^2 value but apply ecf afterwards** **ALLOW** ecf from candidates q^2 value (likely to be 0.87 or 0.9 (if candidate's $q^2 = 0.75$)) **ALLOW** ecf for p from candidate's calculated q value, (if q value between 0 and 1) **IGNORE** % values given for p (e.g. 50 % for 0.5)
4	(b)	(ii)	*in the pet shop* **1** population is , small / not (sufficiently) large ; **2** not all members of the population are breeding ; **3** *idea that* mating is not random ; **4** *idea that* migration / emigration / immigration , is occurring ; **5** *idea that* the non-brown rabbits could be colours other than white ;	2	**IGNORE** ref to (natural) selection / mutation (as these do not apply to the 'artificial' population in the pet shop) **IGNORE** 'albinos are infertile'
			Total	10	

Question			answer	Marks	Guidance
5	(a)		sex linkage / sex linked **;**	1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **ACCEPT** non-autosomal linkage
5	(b)	(i)	Z^BZ^b barred male **;** Z^BW barred female **;** Z^bW non-barred female **;**	3	If no gender given, **AWARD** one mark only if **all three** adult colours correct If no colours given, **AWARD** one mark only if **all three** genders correct **CREDIT AW** for 'barred' e.g. 'black (feathers) striped with white (bars)' **or** 'striped / stripey'. **CREDIT AW** for 'non-barred' e.g. (all) black / not striped.

Question			Answer	Marks	Guidance
5	(b)	(ii)	<table><tr><td>parent phenotypes:</td><td>barred female</td><td>non-barred male</td></tr><tr><td>parent genotypes:</td><td>Z^BW</td><td>Z^bZ^b ;</td></tr><tr><td>gametes:</td><td>Z^B and W</td><td>Z^b (and Z^b) ;</td></tr><tr><td>F1 genotypes:</td><td>Z^BZ^b</td><td>Z^bW ;</td></tr></table> *F1 day-old chick phenotypes* *male* black (body) with a white spot (on head) ; *female* (all) black / black body and head / black with no white spot (on head) ;	5	If symbols other than those given (B and b) are used (e.g. A and a), penalise once and then apply ECF. If X and Y are used instead of W and Z, penalise once and then apply ECF. If alleles put onto the W, penalise once and then apply ECF. **ACCEPT** W written before Z, or other order change eg Z^BZ^b as Z^bZ^B. Gametes must apply to candidate's stated parent genotypes – apply ECF. **IGNORE** genotype repeated (i.e. no space between the gametes). **CREDIT** F1 genotypes in any order **IGNORE** repetitions such as each genotype stated twice. Apply ECF if genotypes match gametes given. F1 genotypes and phenotypes should match, including repetitions if given. Apply ECF **DO NOT CREDIT** adult phenotypes
5	(c)	(i)	homozygous recessive ;	1	**ACCEPT** reverse word order **IGNORE** double
5	(c)	(ii)	(all are) white ;	1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
			Total	**11**	